Teacher design knowledge and beliefs for technology enhanced learning materials in early literacy: Four portraits

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Teacher engagement in the design of technology-rich learning material is beneficial to teacher learning and may create a sense of ownership, both of which are conducive to bringing about innovation with technology. During collaborative design, teachers draw on various types of knowledge and beliefs: know-what (facts, information); know-why (principles, beliefs) and know-how (ways to shape learning materials and activities). The goal of the present study was to understand the nature of individual teacher contributions during the collaborative design of learning materials and activities for early literacy. Through interviews, teacher knowledge and beliefs related to use of technology for early literacy were investigated. Thereafter, teachers collaboratively designed learning materials and activities for use with PictoPal (a technology-rich environment for early literacy). Analysis of design talk that occurred during the design of PictoPal resources showed that teachers differ in the kinds of design knowledge they explicate during design. Of the four teachers, two teachers were inclined mostly to express know-how, one teacher proportionally expressed more know-what, and one teacher more know-why. Given the variety in knowledge and beliefs among teachers, practical implications for supporting such diversity during collaborative design are discussed.

Tags

Teachers as designers; Technology-enhanced learning; Teacher knowledge and beliefs

1. Introduction

Successful and sustained implementation of innovation in education succeeds or fails with the commitment of teachers (Clandinin & Connelly, 1992). While some teachers may choose to innovate of their own accord, many feel compelled to do so while tackling the complex challenge of translating abstract curricular goals into concrete learning materials and activities. For most, recognizing how affordances of technology could be used as part of such resources is an even greater challenge. The active involvement of teachers in determining the nature and content of innovation contributes to its ultimate success (Penuel, Fishman, Yamaguchi, & Gallagher, 2007).

Few teachers innovate with technology in complete isolation. Though the frequency and intensity varies greatly, most teachers seek inspiration, guidance or support through collaboration with immediate or distant colleagues. Increasingly, and especially for technological innovation, teachers work together in teacher design teams (TDTs). Implementation of technology in education has a better chance of success when teachers are engaged in TDTs (Huizinga, Handelzalts, Nieveen, & Voogt, 2014). In part, this is because participation in design teams contributes to a sense of ownership, which supports the

implementation of innovation (Cviko, 2014). Also, engagement in collaborative design is beneficial for teacher learning (Voogt, et al, 2011) which in turn supports innovation.

Successful TDT work depends largely on teachers reaching a shared vision (Huizinga, 2014) and communicating well with each other (Handelzalts, 2009) as well as procedural support (Albashiry, Voogt, & Pieters, 2015). Previous studies have examined closely how TDTs function as groups (Boschman, McKenney, Pieters, & Voogt, in press; Boschman, McKenney, & Voogt, 2014, 2015). This study seeks to understand how individual teacher contributions shape the shared vision and the technology enhanced learning materials that are designed. It portrays how teachers use their knowledge and offers potential anchor-points for supporting them.

2. Conceptual underpinnings

For decades, it has been accepted that teacher knowledge and beliefs underlie teaching practices (Verloop, Van Driel, & Meijer, 2001). Teachers' knowledge and beliefs are intertwined (Pajares, 1992), and they are used not only in the classroom, but also when teachers design materials, lessons and activities. Research has shown that teachers draw on their own private understandings as they design technology-enhanced learning, and that this can influence technology integration practices (Churchill, 2006).

Shulman (1987, p. 14), has long argued that reform and innovation in teaching must take into account how teachers use the knowledge base of the profession. He discusses the process of pedagogical reasoning, which "… involve[s] a cycle through the activities of comprehension, transformation, instruction, evaluation, and reflection." Tempering views that focus on specific behaviours or processes, the concept of pedagogical reasoning emphasizes the intellectual basis for teaching performance. Accordingly, to understand and support the professional development of those participating in TDTs, investigation is warranted into the knowledge shared and used by teachers in design.

Looking specifically at the design of technology enhanced learning, McKenney, Kali, Markauskaite and Voogt (2015), describe different kinds of knowledge and beliefs that underpin teacher abilities to 'engage skilfully in design' (p. 3). Three types are particularly relevant to this study, which seeks to understand how individual knowledge and beliefs contribute to collaboratively designed technology resources for early literacy: know-what, know-why, and know-how. Know-what refers to a teachers' fundamental knowledge base, which consists of conceptual knowledge and facts such as subject-matter content and pedagogical theories. Know-why pertains to a teacher's knowledge and beliefs about principles of learning and teaching. Know-how is a teacher's skill to produce what is needed and can include learning materials, instruction or classroom management. This last category can include design thinking[1].

The knowledge that teachers have and use becomes visible during discourse with colleagues. When teachers replay previous experiences and rehearse future ones, they involve one another in sense-making through emotional and cognitive engagement (Horn, 2010). By investigating TDT talk, we can gain insight into the kinds of knowledge teachers draw on while generating ideas, weighing alternatives, mapping the innovation, discussing potential (desired and undesired) consequences and planning for enactment. TDT conversations during the creation of technology-enhanced learning opportunities provide windows into how teachers share and use their own knowledge when innovating with technology. Thus, this study was undertaken to investigate: What kinds of design knowledge and beliefs (know-what, know-why, know-how) do individual teachers have and use during collaborative design of instructional material to be used in a technology enhanced learning environment for early literacy?

Method

A multiple case-study approach was employed with four kindergarten teachers in the Netherlands. Teachers were the unit of analysis. Data representing teacher knowledge and beliefs were collected through interviews and analysis of their contributions to design team conversations.

3. Participants

Four teachers from one school voluntarily participated. They responded to an open call for kindergarten teachers interested in developing their own classroom innovation for early literacy, using an existing learning environment called PictoPal. The teachers explained that they volunteered because they wanted to learn about and develop new ways of integrating technology in kindergarten. Within the framework of the PictoPal learning

1 Design thinking includes cogntion about the design process itself, including efforts to understand, observe, take points of view, ideate, prototype and test. The design thinking mindset includes: human-centeredness, empathy, mindfulness of process, culture of prototyping, a "show don't tell" approach, bias toward action, and radical collaboration.

environment, the teachers were encouraged to design learning activities as they saw fit. As such, the innovation was teacher-led and researcher-supported. One teacher (Henriette) was formally the lead kindergarten teacher. She acted as liaison and coordinated with the researcher to arrange introductions and workshops that could also be attended by three other teachers (Esther, Gees and Sylvia). The teachers knew each other well and had worked together for several years. The team of teachers is considered representative of other teams of kindergarten teachers in the Netherlands.

4. Procedures

Teachers' individual design knowledge was first explored using a semi-structured interview. Following these interviews, the four teachers worked together in a TDT to create a set of learning materials for use in their own classrooms. Because examples were available and the basic structure of the learning environment was already determined, their work could be described as adoption and adaptation. Over the course of three design workshops, they created instructional materials for PictoPal. PictoPal is a learning environment featuring on- and off-computer activities to develop understanding of the functions of print (Cviko, McKenney, & Voogt, 2014). With PictoPal, teachers design activities around a specific theme (in this case, they chose 'farm'). Using the on-computer activities designed by the teachers, children construct written products with the aid of the computer. Their prints are then used in off-computer classroom applications (also designed by the teachers). The workshops were facilitated by a researcher (Facilitator, F), monitoring the design process, and an early literacy expert (EL), offering content expertise. The EL was an accomplished teacher trainer in the area of early literacy and currently held a teaching position at a school for special educational needs.

5. Instruments & Analysis

The interviews and design conversations were transcribed. Thereafter, qualitative analysis began deductively (Miles & Huberman, 1994), by looking for evidence of different kinds of knowledge described previously (know-what, know-why, know-how). In the interviews, this was done for each response, and summaries were generated. This resulted in portraits of the knowledge and beliefs each person had articulated.

For the design conversations, each speaking turn was coded as relating to know-what, know-why, know-how (or none). Then, the contributions per knowledge type were counted. To ensure quality in the analysis, the interview summaries as well as the coded conversations were discussed in the research team until consensus was reached.

Results

6. Henriette

Interview data

At the start of the interview, Henriette defined early literacy: "It means that children become aware that letters are not abstract but are meaningful." For Henriette, early literacy means learning to understand the link between sounds and letters. She considers this development as: "… an exploration: 'hey, but if you remove the first sound and you replace it with another sound, then it becomes…' and that 'expedition', is just so wonderful to witness in kindergartners" (know-what). The appropriate way to teach early literacy in kindergarten is play-related and exploratory in order for children to make discoveries about literacy (know-why). The zone of proximal development, as is implicitly mentioned here, is also specified further: "You keep searching for the next step, and if they get it, then reading will develop in and out of itself." Furthermore, Henriette mentions invented spelling (children writing words using the rudimentary knowledge of spelling conventions) as appropriate (know-why); developing skills for listening and whenever necessary call in the aid of a speech therapist (know-how).

Henriette's repertoire for action (know-how) is extant and aligns with knowing what, especially in specifying what kind of activities can be conducted to stimulate awareness of the meaningfulness of letters: "[reacting on how learning to write should look like] it's okay with junior kindergartners to… it may just be scribbles, drawings… as long as they think 'it's my grocery list." Next to writing she also mentions book reading activities, activities that involve telling stories to each other and listening. Book reading was also used as a learning situation that could directly be linked to writing activities: "reading occurs in an interactive way." All children's activities are accompanied with writing: "what are you building? A garage, well let's write that down." Henriette expressed curiosity in learning how to use ICT effectively and showed a positive attitude towards ICT in kindergarten education.

Design talk

The results of the count of Henriette's utterances showed that 24 (15%) individual utterances were coded as know-what; 34 (21%) as know-why and 101 (64%) as know-how. Compared to her team members, Henriette provided the most contributions (159 utterances) to the conversation. She often initiated new conversations and also provided the most reactions to the language expert. Furthermore, Henriette was the team leader of the kindergarten team.

Know-what. Understanding what early literacy means as well as explaining reading-related concepts is explicated as know-what. For instance, in response to F's opening question ("What do you think is important in early literacy education?"), Henriette stated: "Early literacy means, functional writing, scribbles can be letters…". During the remaining part of the first workshop, Henriette often was the first to respond to either the facilitator or the language expert. For instance, Henriette tells the early literacy expert that all kindergarten teachers at her school "strongly address phonological awareness". In another part of workshop three, she recognizes invented spelling (children write words according to the way they understand spelling rules) as appropriate, especially when done by the children who are more developed in early literacy. She envisions them using PictoPal by stating: "You would really have to listen carefully to the sounds" (know-what). This last statement differs from the other two statements made earlier. Functional writing and phonological awareness are not followed by an explanation of what these concepts mean, in contrast invented spelling is explained and underlies one of the decisions in PictoPal: children may use their own way of writing a word to explore the link between sounds and words.

Know-why. During the first workshop she states: "You make use of the zone of proximal development." This remark was in response to Gees who tells that teachers monitor the development of children. Henriette's remark is part of a larger episode in which all teachers share their beliefs about early literacy education.. "You try to enact the real world as much as possible…we go to a 'store'… making it really meaningful for children." Also in the first workshop she repeatedly states that writing activities should be meaningful. Henriette responds to a video-vignette: "…what's the use of that? You might as well put hieroglyphs there." To her, when children write a word, they should be able to understand what they write. Furthermore as she also adds, children may recognize words. "Good sentences, for me that's really important" Also, in response to the early literacy expert mentioning the appropriateness of using articles with verbs she repeats by stating: "It's really good to train this immediately, I guess?" (see Figure 1). Also, know-why is expressed when Henriette clearly sees that the affordance of PictoPal not on training the sound-letter link, she states: "This is not going to replace our phonological awareness. PictoPal addresses a different goal, and should be set up as such."

Tables and figures

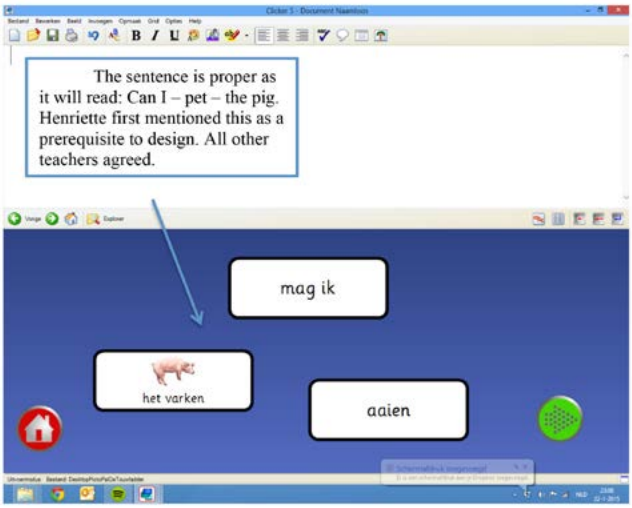

Figure 1. On-screen activity in which children have to listen in order to make proper sentences of the three individual parts

Know-how. Most of Henriette's contributions pertain to Know-How: various *words and categories of words* regarding the theme 'Farm' (the central theme of the design activities). She mentions *all kinds of written material* such as a mind-map of words, a small list, and a letter as being the appropriate written products children will work on. Third, when discussing particularities of the letter, Henriette proposes various kinds of sentences ("I am a horse, or a…" "I give, milk or eggs"). Finally, she is also very active in proposing activities to be done *with the written product,* like making a drawing with a sentence or actually visiting the farm and reading the lower –case containing an informative question: "Can I pet the sheep?".

7. Gees

Interview data

Similar to Henriette, Gees defined early literacy as becoming aware of the meaning of letters. She also explains: "…children

grow up in a literacy rich environment, starting at very young age, everything in their environment is with letters, so it's very meaningful for children" (know-what). In contrast to Henriette, Gees does not provide a rich description of early literacy, rather she states: "… that these can be letters and that these can be used to make words (know-what). And early on, you may say: "just draw it, a message, letter or something like that" (know-how). Gees explains what she does to stimulate early literacy but also explains how she thinks early literacy develops: "Just see how they engage with it. Do they write, at some point they start writing their own words, or they'll ask things, and by breaking words down to individual sounds and putting them back together" (know-why). Finally, Gees provides detailed accounts of various activities regarding writing letters, making written objects, writing ones' own name (know-how). For example she states: "this morning we did a game with the letter 'r' from 'rug' and children had to search all sorts of other objects with the letter 'r'." Also, she explains how she writes down words that children are interested in learning about. Gees expresses curiosity in effective ICT use and furthermore expresses a positive attitude towards ICT in kindergarten.

Design talk

The results of Gees showed that 15 (19%) individual utterances were coded as know-what; 9 (11%) as know-why; and 56 (70%) as know-how. Gees provided less input to the conversation (81 utterances) than Henriette and Esther, but more than Sylvia.

Know-What. Know-what reflects two topics: first, Gees reminds the other three teachers that during the time-period in which PictoPal is implemented, 'The farm' is the theme that is central to all learning activities in both kindergarten groups. This theme was established earlier that year by a committee of which Gees was one of the members. At the end of workshop 1, Gees is the one to mention this to all other teachers. During the actual design, Gees and Henriette both brainstorm on categories of words that could be meaningful in the theme 'Farm'. For instance: "Machines of the…how do you call that." And "…crops that grow on the pastures."

Know-Why. Gees states: "We have to monitor the development", also she mentions on writing activities: "sometimes they [children] want the correct word. You have to write that down." During design, she first poses the question whether to use capitals or not. She prefers not to, as she mentions this being the standard at their school (see Figure 2). Second, in response to Henriette, she confirms that pictograms support vocabulary development. Third, she proposes that a screen for making a list should be divided into two: one depicting words the other, depicting a corresponding Pictogram. The reason being, that this would be much more effective in lay-out. However, this is not being taken up by the other teachers (see Figure 2).

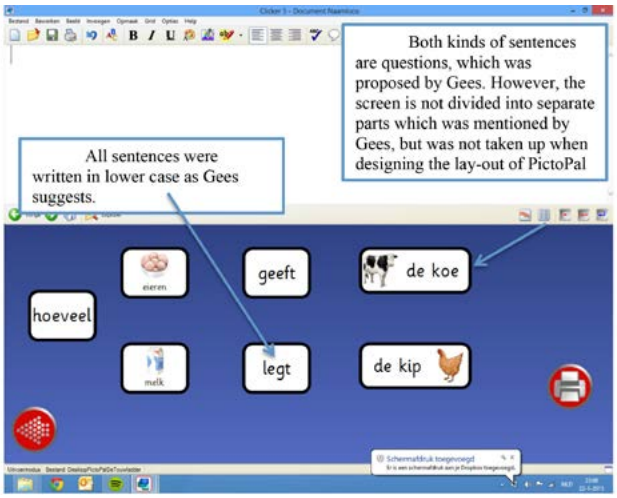

Figure 2. On-screen activity showing a more elaborate letter that is actually used on a farm to pose a question, notice the absence of capitals which was put forward by Gees

Know-How. During workshop 1, after an initial look at PictoPal, Gees asks: "And do we need parents to help children with these activities?". F suggests to do so. The team decides to try and find parents for computer support. Also Know-How is expressed by Gees by proposing various activities like making a letter for the farmer, but also by discussing how the letter is actually being used on a farm, how children learn how to pose a question (before actually writing the letter)(Figure 2). Second, she also expresses how various written products can be used in subsequent off-computer activities.

8. Esther

Interview data

Similar to Henriette and Gees, Esther also defines early literacy as becoming aware of the meaning of letters (know-what). Esther furthermore explains differences between junior and senior kindergartners in the goals that each of them has to attain. "At the end of junior kindergarten, the goal is to write one's own name, at the end of senior kindergarten, they have to write their own name, that of a friend, mummy, daddy" (know-what).

On what is appropriate practice in early literacy, Esther explains: "especially by creating a safe environment in which children will talk" Also, in such an environment, the zone of proximal development is addressed: "Do not present children with something they are not ready for, you should always keep that in mind I think" (know-why)

Like Henriette and Gees, Esther also provides example reading activities, writing activities and listening activities (know-how). Some examples to illustrate this: "in the 'spring-book' they write words that are written on wildcards. And we have a 'letter-table', which is there when they start writing." "Often, children will come to you "miss, can you write this down for me?" then I write it down and then they may copy this. Finally, she also explains that she uses ICT for early literacy. "I really don't have a goal. We have all kinds of activities, children may just pick one at random, for instance 'Vocabulary' or 'Treasure Chest' (both are common Dutch early literacy related software applications). Similar to the other teachers, Esther also shows a positive attitude towards ICT.

Design talk

The results of Esther showed that 7 (5%) individual utterances were coded as know-what; 29 (19%) as know-why and 115 (76%) as know-how. In total Esther provided slightly less input to the conversation as Henriette (151 utterances). Most codes were coded as know-how, the percentage exceeds the percentages of know-how coded utterances found in the other three teachers.

Know-What. Know-what is expressed by explaining that early literacy means engaging children in all sorts of writing activities. Also she mentions that children make discoveries about written material. Furthermore, know-what is also expressed when discussing the theme of PictoPal with Gees.

Know-Why. Esther stresses the zone of proximal development: "I find it important that early literacy development should occur by itself. If we sit a child down and tell him, you have to write this letter, that does not stem from their own fantasy." Second, Esther acknowledges the support from the early literacy expert and adds: "Yeah, it's also how you would do this [using an article] in spoken language." Third, in response to Gees, Esther also provides reasons to use lower-case letters. Fourth, when discussing the goal of PictoPal, she also concludes: "But this is also for vocabulary development!" Which is agreed upon by the other teachers and the early literacy expert as well. Finally, Esther also explicates know-why when she stresses the need for children to *write proper sentences* when using PictoPal (see Figure 3).

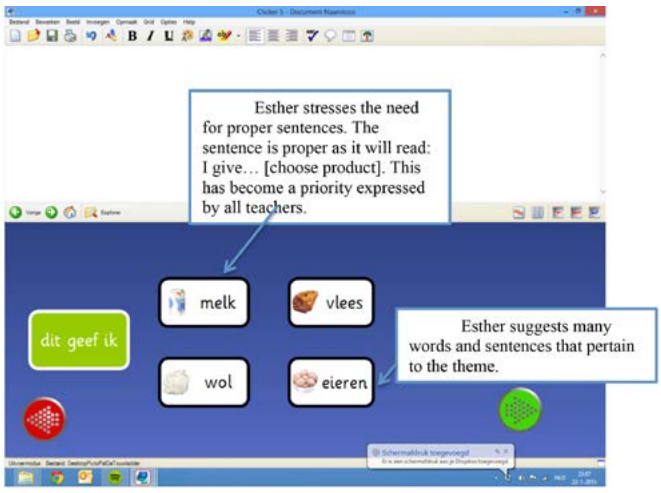

Figure 3. On-screen activity showing two screens, one in which children choose an animal, the second in which the products that belong to these animals have to be chosen.

Know-How. Similar to Henriette and Gees, Know-How is expressed when discussing various activities on the computer, words and lay-out of the computer screen. However, Esther provides most of the contributions to the actual design of PictoPal. Also, she frequently makes most of the initial proposals for certain parts of PictoPal. For instance, she is the first one to propose making a letter (which later on is planned to be used during an actual visit to a farm). Also, Esther expresses know-how as: what letter to be written by children, what kind of sentences and words, and the letter is used in play. Finally, Esther repeatedly finds words and sentences that pertain to the theme, like kind of animals and properties of animals (a cow provides milk). When discussing letters, she often comes up with various sentences and parts of sentences (see Figure 3).

9. Sylvia

Interview data

Like the other three teachers, Sylvia defines early literacy as becoming aware of the meaning of letters as is expressed by her statement: "Children start with scribbles, they see examples and start imitating, grocery lists and it starts with small drawings and ultimately they become aware, like 'hey, these are actually letters and then they start writing." Ultimately they make a discovery: "hey, there's actually something written up there" (know-what).

Also, similar to the other three teachers, Sylvia states the importance of building a learning environment that engages children in writing. She states: "it's important that it's really alive." Similar to Esther, Sylvia also stresses the importance of a safe environment: "safety is the first basis." "Soothing, providing compliments, that a child thinks 'I can do it!." (know-why). As with all three other teachers, Sylvia expresses a positive attitude towards ICT and even explains why she does not use ICT in her teaching of early literacy and how much she resents this. First, she mentions the lack of an interactive whiteboard: "Right now, you use one computer in front of an entire group, half of them can't see it, and if you have an interactive whiteboard, you can do more… I think we are getting them though" (know-how). She also thinks ICT is valuable: "… it's valuable for them. Also when they play games, they will learn some basic skills."

Sylvia mentions learning-activities (know-how) similar to all three other teachers, for instance: "We use word-cards, writing corner".

Design talk

The results of Sylvia showed that 7 (11%) individual utterances were coded as know-what; 18 (33%) as know-why and 32 (56%) as know-how. Compared to the other teachers relatively many utterances were coded as know-why. Sylvia provided the least input to the conversations (57 utterances).

Know-What. Utterances by Sylvia coded as know-what only were made in response to Gees about the theme.

Know-Why. Sylvia is very detailed in providing reasons for how she teaches early literacy. On the zone of proximal development she explains: "Keep going up a step" and "especially by letting it come out of themselves." Also, in response to Gees (sometimes children want to write a word properly) Sylvia states: "but then they would ask for it." Also, she often provides reasons on other teachers' comments. For instance Esther states: "…some children were writing a flag, and then you go like 'Netherlands', what's the first letter, and that one, we write down." Sylvia comments: "Then it's more meaningful to them." During design, similar to the other teachers, Sylvia stresses the importance of proper sentence building, as she provides a reason: "You are an example" "they have to be good [sentence]". Finally, she makes an interjection, on a proposal to include an exercise that will involve linking male and female versions of animals (a mare and a stallion). She states: "For some children that's too difficult." For the other teachers this is enough to let go of the proposal for male and female animals.

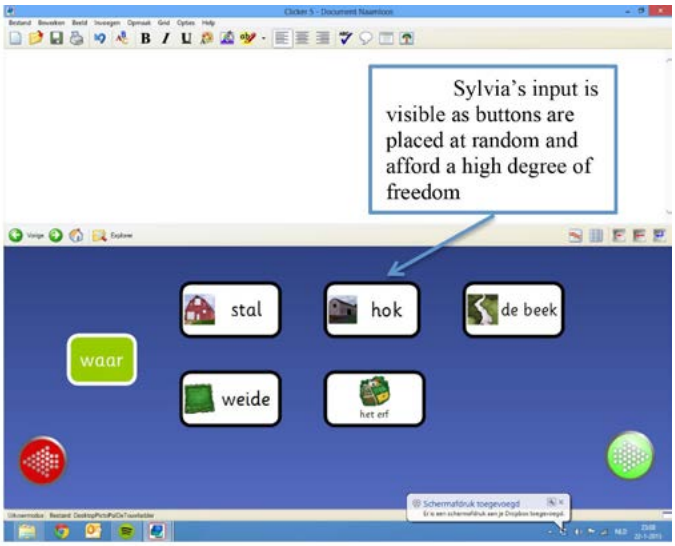

Figure 4. On-screen activity, in which children choose a main-character and a second one where they choose a situation as input for creating their own story.

Know How. Similar to the other teachers, Sylvia expresses know-how when brainstorming on the actual design of PictoPal, words and sentences to be used and activities that can be done with the written material made with PictoPal. However, she makes less contributions that refer to know-how than the other three teachers. Although her comments are short, other teachers agree with what she says. For instance, she mentions, during the end of workshop 3, that lesson 7 and 8 might be put on hold. Sylvia also mentions that during the sixth week, childrens' on-screen activity should show less support. This would allow for the activity in which children make their own story using only single words within a specific theme. Figure 4 shows how this proposal is designed: five options for words are given within the category 'where'. Children listen to the words and then decide which word fits best in their own self-made story.

Discussion

Synthesis

This study investigated the knowledge and beliefs individual teachers have and use during collaborative design of technology enhanced learning materials for early literacy. The findings of the interviews as well as findings from design conversations reveal key themes in the knowledge and beliefs shared by

teachers as they innovate for their own classrooms. Specifically, the participating teacher discussions related to:

- Zone of proximal development.
- Play and authentic activity are important.
- Children develop early literacy in and by themselves, through discovering the link between sound and words.
- Children should write down words, only when they know the meaning of those words (in response to the video-vignette, showing a teacher who doesn't).

During the design of PictoPal, all four teachers agreed on these design decisions:

- Goal of PictoPal is vocabulary development and learning to make proper sentences.
- This goal should be reached as children make a list, a lower-case letter and categorize words on the computer.
- These written materials are then used in play as well as authentic activities such as visiting a farmer.
- Ample proposals for on-computer and off-computer activities in which children make a variety of written materials (lists and kinds of letters) are made by all teachers.

This agreement formed the foundation for further design work. Findings however also highlight individual differences in design knowledge expressed in interviews and design talk; these are summarized in Table 1. Know-what was hardly expressed by all four teachers, as was know-why. For instance, teachers agreed that the material designed should target vocabulary development, which was translated into concrete activities and material such as making a list of words.

	What	How	Why
Henriette	24 (15%)	101 (64%)	34 (21%)
Gees	15 (19%)	56 (70%)	9 (11%)
Esther	7(5%)	115 (76%)	29 (19%)
Sylvia	7 (11%)	32 (56%)	18 (33%)
Total	53 (13%)	304 (65%)	90 (22%)

Table 1. Percentages of codes (what, how and why) found in design talk for all four teachers.

In solving design problems, individuals may differ in their problem-solving approach. Dijkstra and Van Merrienboer (1997) distinguish three kinds of problem solving activities: (a) categorization or description problems, (b) interpretation problems, and (c) design problems. Accordingly, these kinds of problems require (a) conceptual knowledge (similar to know-what); (b) hypotheses, theories and principles (know-why); and (c) design rules to actually build artefacts (know-how). Table 1 shows percentages of codes on the different kinds of knowledge and beliefs identified.

When compared to the overall percentages, design problem solving (with know-how) is at the heart of the teachers design talk. However, when comparing individual distributions in percentages to the average, differences emerge. Henriette's and Esther's distributions were in line with the average. The large absolute amount of contributions that both teachers made weighs in on this distribution. However, Gees and Sylvia not only have less input (in terms of absolute amount of contributions), but they also differ in the kind of input they bring to the conversation. Gees brought in more know-what topics; Sylvia brought in more know-why information. Gees provided information on the specific theme; Sylvia explicated principles and beliefs on how to teach early literacy in education.

Although not explicitly investigated in this study, the teachers' sense of community and unspoken power dynamics may have influenced their design conversation engagement. The team worked quite naturally together and, although some members were more quiet than others, none appeared to feel uncomfortable. Still, it is notable that the lead teacher (Henriette) talked more than the others during the conversations.

Also notable is the fact that the teachers felt substantially challenged by this work. We bear in mind that the tasks were heavily scaffolded by the presence of existing materials (not requiring the creation of something completely new) as well as researcher-support. Our personal observations suggest that the task of adopting and adapting existing materials appeared to be within their own zone of proximal development. However, the degree to which it was challenging gives us cause to question the extent to which it would be productive to – as is quite often the case - challenge teachers to innovate from scratch.

10. Recommendations

Design is mostly intuitive (Boschman, McKenney & Voogt, 2014), which was also shown in this study by the large amount of know-how expressed. Facilitators should be aware of the various characteristic design approaches. To engage all TDT participants, and to maximize use of their diverse knowledge to the enrichment of the final designed product, TDT facilitators should not necessarily work toward consensus immediately (a natural inclination for most designing teachers), but explicitly attempt to draw out the varied perspectives and knowledge within the group. Support can then be provided to the design

process by giving information, facilitating discussions, or challenging teachers to explicate their underlying principles (know-why) and conceptual knowledge (know-what). Furthermore, teachers should also be invited to reflect on their know-how. Steering the conversation towards explication of reasoning underlying certain decisions can contribute to professional development.

This was a small-scale study involving four teachers and one innovation, only. Further research with more teachers focusing on various domains and levels of schooling is needed to explore additional patterns and variety in the design contributions of individual teachers. Future investigations could replicate the conversation analysis approach described here, possibly in combination with the phases of pedagogical reasoning described earlier (Shulman, 1987), or specific phases of design. This could give more insight into not only the kinds of contributions teachers make, but also portray relationships between contribution types and stages of innovation work.

11. Conclusion

Overall, the findings of this study suggest that mostly, know-how was expressed during design talk. However, as the interviews also revealed, know-why played an important role because it showed to be underlying the know-how. Know-what was hardly expressed by teachers. This study also found differences between teachers. Of the four teachers, two teachers were inclined mostly to express know-how. These two teachers also made more contributions to the design than the other two teachers did. Of the other teachers, one teacher relatively expressed more know-what and one teacher more know-why.

This study highlights the variety in kinds of contributions made by individuals in TDTs and their implications. First, teacher differences yield varied types of design contributions. These can range from considerations of developmentally appropriate practice ("You make use of the zone of proximal development") to concerns about facilitating enactment well ("And do we need parents to help children with these activities?"). Second, the varied design contributions enrich the pedagogical reasoning in the discussions as well as the products themselves (e.g. "We have to monitor the development ... sometimes they [children] want the correct word. You have to write that down").

With the ultimate goal of understanding and supporting the professional development of those participating in TDTs for technology innovation in kindergarten, this study investigated how individual teacher contributions shape the design conversations and resulting products. Acknowledging that design work requires pedagogical reasoning, the present study portrays how teachers share and use their knowledge in this collaborative process. This study emphasizes kinds of differences that can be anticipated among teachers, and offers recommendations for supporting them. Thus, this research makes modest but important steps toward understanding and facilitating teacher-led innovation.

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